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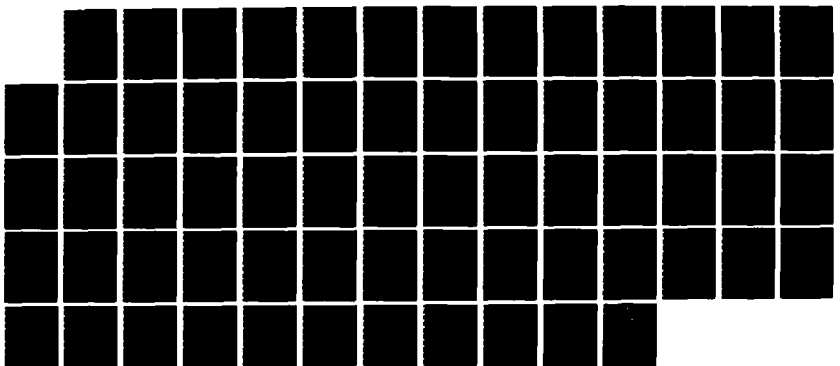

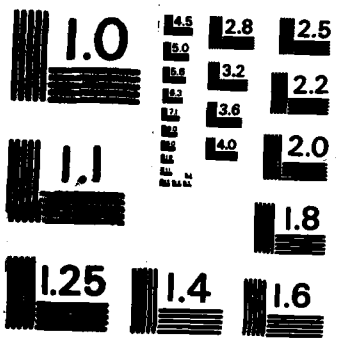

BRMC-84-5087

ACQUISITION COST REDUCTION THROUGH IMPROVED PRODUCTION/INVENTORY SYSTEMS

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30 August 1985

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Unliquidated progress payments, or work in process (WIP), cost the Department of Defense several billion dollars per year to finance. These payments represent the value of property paid for by the Government but not yet received. This study developed a formula to determine the present and future value of the holding cost of WIP and to estimate the potential savings of reducing the average WIP. The study indicates that by using a ratio of annual liquidated to average unliquidated progress payments, Government representatives can monitor how effective contractors are in managing Government-owned WIP represented by average unliquidated progress payments.

The study proposes a simple addition to the CMSEP which will focus a contractor's attention directly on WIP levels and on those planning factors which are crucial to efficient procurement and production planning. It also proposes an incentive clause be developed which would allow a contractor to participate in savings when WIP holding costs over a contract's life are less than a negotiated target or bear a portion of the costs when the target is exceeded. Keywords:

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SUMMARY

The government's annual cost of financing government owned work in process (WIP), unliquidated progress payments, may exceed several billion dollars. WIP financing costs are directly related to the effectiveness of contractors in performing the basic Production and Inventory Control (PIC) tasks of planning, scheduling, and control. Master production scheduling, requirements planning, detail scheduling, purchasing, and shop floor control are present in every production system and lead times are key factors which influence the average size of WIP.

Very little specific research was found on measuring WIP management effectiveness; however, nine potential performance measures were selected and grouped into three classes--accuracy, utilization, and productivity. Inventory turnover was singled out as the most promising performance measure and used as the ratio of liquidated progress payments to unliquidated progress payments to measure government owned WIP turnover.

Contractors are narrowly concerned with satisfying a contract's requirements of cost, schedule, and performance. As a result, a contractor may accomplish material and production activities prematurely resulting in excessive government owned WIP. The cost of financing this WIP is borne by the government but does not show up on the Department of Defense's accounts.

The Department of Defense has developed a typical contract from information obtained from twelve recently completed contracts for major end items. This model was evaluated by changing the time at which material and direct labor costs were incurred. The ratio of contract cost to average unliquidated progress payments was calculated for various assumptions as well as the actual cost to finance work in process. A formula was derived to determine the present value and the future value of the holding cost of work in process. These descriptions were then used to estimate the potential savings of reducing the average work in process.

Seven defense contractors provided information about their annual liquidation of progress payments and their average unliquidated progress payments. The ratios of these two variables ranged from .07 to 10.01 indicating significant variability in some contractors' level of defense work. Those contractors with apparently stable defense workloads had ratios just above 1.0. A number of different sets of assumptions about contract requirements were evaluated by using the Department of Defense typical model and consistently produced ratios much higher than reported by the contractors. This information is inconclusive but it does suggest that significant reductions in work in process are possible.

The final report included a proposed Management System Indicator (MSI) to be added to the Air Force's Contractor Management System Evaluation Program. The MSI would focus contractor and government attention on the levels of work-in-process and the need for accurate planning factors. In addition; the report recommended that an incentive clause be developed with a target for work in process holding costs for a given contract. This would allow the contractor to share in the savings or added cost if actual holding costs wre below or above the target.

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CHAPTER I

Study Overview

1.0 Background

Manufacturing organizations use production/inventory control systems to develop the proper calculation of material requirements and components to support the manufacturing rate and the determination of manufacturing lot quantities. The central functions of effective control systems are concerned with maintaining minimum investment in material consistent with operational requirements. The goal is to ensure that there is an adequate stock of all recurring and nonrecurring items to maintain operations and to keep investment in materials and work in process at optimum levels.

Two basic kinds of problems exist in poorly designed production/inventory control systems that lead to increased manufacturing costs and decreased productivity. One problem is the use of "workarounds" caused by parts shortages, and the other is increased holding costs caused by premature material acquisition/production. These holding costs include the cost to maintain inventory levels, rework or scrap costs caused by obsolescence, material losses, and the

cost of capital associated with work in process and stockroom inventory.

The potential dollar/manpower savings from improved production/inventory control systems are significant. Such systems would also lead to reduced manufacturing overhead in contractor facilities, which would provide further savings. The Defense Audit Service Report No. 81-031, dated December 18, 1980, stated that "on December 21, 1979, the 7 AFPROs included in the audit had 159 contracts with unliquidated progress payments amounting to $3.2 billion." Unliquidated progress payments represent the value of property paid for by the government but not yet received, and this property, paid for but not received, is identical to "work in process" as used in this study. Treasury bills maturing in six months were yielding 9.2 percent on 1 March 1985. At this rate, the annual cost of holding work in process for the 7 AFPROs is approximately $294 million. The annual cost for all 81 contractors with plant representative offices may easily exceed several billion dollars.

The objective of the Acquisition Cost Reduction Through Improved Production/Inventory Systems study (hereafter called the PIC study) is to develop an effective system to assist system program office and contract administration people in measuring the performance of a contractor's production/inventory control system. Such a system should include methods to estimate savings from proposed system

changes. It should also include strategies to prevent adverse impacts on logistics support resulting from changes which reduce production/inventory control systems costs. All evaluation guidelines will be consistent with contract administration emphasis on "compliance with contractual terms for schedule, cost, and technical performance [quality] in the areas of design, development and production" [reference Federal Acquisition Regulation (FAR) 42.303(a)(40)].

DOD plant representatives responsible for contract administration have specific administrative functions requiring evaluation and surveillance of a contractor's production and purchasing system [reference FAR 42.302(a)(40) & (50)]. A review of the Armed Services' policies regarding their plant representatives' duties shows that the Air Force Contract Management Division (AFCMD) has an excellent program to monitor a contractor's performance. AFCMD's policies are contained in AFCMD Regulation 178-1 dated 25 March 1982, titled Contractor Management System Evaluation Program (CMSEP). This regulation serves as an excellent example both for understanding how plant representative offices currently perform their surveillance duties, and of the form that implementing guidelines for PIC improvements should take. The current study includes a brief analysis of two Air Force Plant Representative Offices regarding their use of CMSEP.

The study uses as its population those manufacturing firms which have plant representative offices, i.e., Defense Contract Administration Services Plan Representative Offices (DCASPRO), Army Plant Representative Offices (ARPRO), Naval Plant Representative Offices (NAVPRO), and Air Force Plant Representative Offices (AFPRO). DCAS has 40 such offices, followed by the Air Force with 25, the Navy with 13, and the Army with 3 (reference DOD 4105.59-H dated January 1984). Eight of these 81 PROs are located in the DCASR Atlanta region and provided the basic source of on-site data for the PIC study.

1.1 Study Tasks

The following phase and task descriptions are quoted from the study contract's work statement:

> 4.1 Conduct the Study
>
> 4.1.11 PHASE I Develop performance measures for evaluating the effectiveness and appropriateness of defense industry contractor production/inventory control systems. Differentiate between aircraft, avionics, electronics and other defense industry types of manufacturing processes as appropriate. Develop standard criteria against which a given production/ inventory control system can be measured. Contractor shall not proceed with Phase II without written notification from the Contracting Officer.
>
> 4.1.2 PHASE II
>
> 4.1.2.1 Develop detailed, micro-economic savings estimation techniques to measure results of changes in a given production/ inventory control system. The savings estimation techniques will be developed using the standard

criteria and performance measures developed in 4.1.1 as a baseline.

4.1.2.2 Develop review procedures for DOD contract administration people to use in evaluating production/inventory control and associated management systems. These procedures will include, but not be limited to, the performance measures and savings estimation techniques developed in 4.1.1 and 4.1.2.1.

4.1.2.3 Identify and develop strategies to prevent adverse cost, schedule or performance impact on logistics support resulting from changes to production/inventory control systems.

4.1.2.4 Develop an implementation guide for application of the measures, techniques, procedures and strategies developed in 4.1.1, 4.1.2.1, 4.1.2.2, and 4.1.2.3. This guide will assist system program office and contract administration people in implementing the measures, techniques, procedures and strategies.

1.2 Phase I Results

The conclusions and recommendations from Chapter VI of the Interim Report, dated 15 March 1985, are cited here for continuity:

6.0 Conclusions

The government's annual cost of financing government owned work in process (WIP), unliquidated progress payments, may exceed several billion dollars as stated in section 1.0. The average size of WIP is directly related to the effectiveness of contractors in performing the basic Production and Inventory Control (PIC) tasks of planning, scheduling, and control. Section 3.1 shows that master production scheduling, requirements planning, detail scheduling, purchasing, and shop floor control are present in every production system. Production and procurement lead times are singled out as key factors which directly influence the average size of WIP. Section 3.2 demonstrates

that the Standard Industrial Classification codes can be used to classify PIC systems based on the product produced by the contractor.

The review of publications from 1976 through 1984, presented in Chapter II, shows that very little specific research has been published on measuring WIP management effectiveness. Nine potential performance measures were selected from this review and discussed in detail in section 4.2. These measures were grouped into three classes: accuracy, utilization, and productivity. Section 4.3 indicates that inventory turnover was the most promising performance measure found. The ratio of liquidated progress payments to un-liquidated progress payments is a measure of government owned WIP turnover.

Section 4.4 discussed various measures of scheduling performance and suggested that tardiness, earliness, and lateness, which are all related to due dates, can be used to develop a conceptual model relating true acquisition cost, schedule, and technical performance. Two conceptual models were presented, one of which, Fig. 4-1a, suggests that true acquisition cost increases at an increasing rate as actions are taken to improve the probability of meeting a scheduled delivery date. The other conceptual model, Fig. 4-1b, suggests that technical performance increases at a decreasing rate as actions are taken to meet a schedule. These two conceptual models, and the discussion in section 4.4, show that a contractor may schedule and accomplish material and production activities prematurely which will result in excessive government owned WIP. The cost of financing this WIP is borne by the government but does not show up on the Department of Defense's accounts.

Chapter V describes visits to Lockheed-Georgia and the Westinghouse Defense and Electronic Center. Both contractors use the performance measures described in Chapter IV, however, neither is directly concerned about WIP. Lockheed uses block scheduling with lead times that are not closely related to actual production times. Westinghouse has a program to improve productivity including reducing lead times. The Air Force Plant Representative Offices of these two contractors were effectively using the Contractor Management

System Evaluation Program (CMSEP); however, this program does not specifically address WIP management.

6.1 Recommendations

a. That the ratio of liquidated progress payments to average unliquidated progress payments be used to measure a contractor's effectiveness in managing government owned WIP.

b. That the conceptual models described in section 4.4 be developed to show the tradeoffs between true acquisition cost, schedule, and technical performance.

c. That phase II tasks be completed and the CMSEP used to demonstrate the implementation of the study findings.

1.3 Summary

The purpose of this report is to present the results of Phase II and recommendations for future action. In addition, subsequent sections will address specific guidance on two items given by the AFBRMC in its letter, subject: Comments on Interim Report for Acquisition Cost Reduction Through Improved Production/ Inventory Systems dated 23 April 1985. Item one requires an "... attempt to correlate dollar savings on actual contracts with actual variation in 'the ratio of liquidated progress payments to average unliquidated progress payments.'" Item two asked that the study "... consider the implementation of surge as a DOD objective. Show where surge begins and good WIP control ends." Item one is covered in Chapter II,

along with the results of task 4.1.2.1 on micro-economic savings estimation techniques. Item two is discussed in Chapter III in conjunction with task 4.1.2.3, which deals with adverse cost, schedule on performance impacts. Chapter IV presents the results of tasks 4.1.2.2 and 4.1.2.4, which address review procedures and provide an implementation guide.

CHAPTER II

Micro-economic Savings Estimation Techniques

2.0 Introduction

Task one of Phase II states: "Develop detailed, micro-economic savings estimation techniques to measure results of changes in a given production/inventory control system. The savings estimation techniques will be developed using the standard criteria and performance measures developed in 4.1.1 [Phase I] as a baseline." As quoted earlier, the interim report recommended "That the ratio of liquidated progress payments to average unliquidated progress payments be used to measure a contractor's effectiveness in managing government owned WIP." This recommendation was accepted by the AFBRMC in its 23 April 1985 letter, cited earlier. The AFBRMC also asked in the same letter: "That you should attempt to correlate dollar savings on actual contracts with actual variation in 'The ratio of liquidation progress payments to average unliquidated progress payments.'" The remainder of this chapter will describe the causal relationship between unliquidated progress payments and possible savings, and evaluate the limited information available

regarding contractor's liquidated and unliquidated progress payments.

2.1 WIP Savings Estimation

The purpose of this task is to establish cause and effect relationships between a performance measure and specific production or inventory actions which can be related to the measure. The measure of productivity that has been selected is work in process inventory, in which the measure of quantity for a contractor is average unliquidated progress payments. Within this section, relationships are defined which exist among work in process inventory, amount of component safety stocks, production lead time and set-up time. These mathematical relationships are for illustrative purposes only, since the exact equations will vary dependent upon a number of factors at each contractor's production facility. These relationships are then used to develop estimations of dollar savings that are possible from a reduction of work in process inventory, and, therefore unliquidated progress payments. Later these relationships will be used to develop appropriate condition questions for the CMSEP to be used by AFPROs in monitoring a contractor's WIP.

2.1.1 Areas of Savings

The primary areas for WIP reduction occur in a firm's use of set-up costs and lead times. If any combination of these factors is greater than necessary, then WIP is larger than required to meet schedule and performance goals. The following discussion illustrates the general relationship between each factor and WIP levels.

2.1.2 WIP vs Set-Up Costs

The relationships among WIP, safety stock, lead times and set-up times can be analyzed through applications of standard inventory models. Using the familiar batch-size model with safety stock, the behavior of finished component cycle stock and its associated safety stock could be represented as in Figure 2.1. Given this model, let

Q(1) = lot size being used in System 1

Q(2) = lot size being used in System 2, with Q(1) > Q(2)

A(1) = setup cost for System 1

A(2) = setup cost for System 2, with A(1) > A(2)

R(cs) = fractional reduction in average cycle stock due to a conversion from System 1 to System 2;
= 1 - [Q(2)/Q(1)]

D = demand rate, i.e., units/year

h = average inventory holding cost per unit per year.

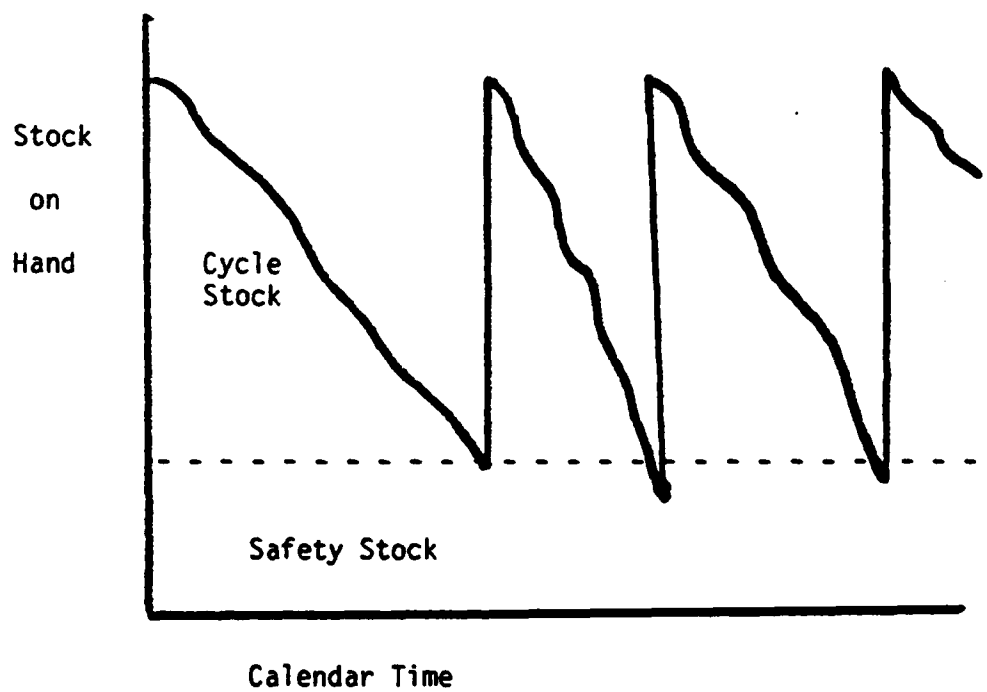

Figure 2.1 Profile of Stock on Hand with Batch-size Inventory Model.

Then, assuming that the unit holding cost is the same under both System 1 and 2, we have

$$Q_1 = [2*A(1)*D/h]^{1/2}$$

$$Q_2 = [2*A(2)*D/h]^{1/2}$$

$$R(cs) = 1 - [A(2)/A(1)]^{1/2} .$$

Figure 2.2 illustrates this relationship for various ratios of set-up cost. For example, given a ratio of set-up times of .8, implying a set-up improvement of 20 percent, the finished component cycle stock will be reduced by about 11 percent.

2.1.3 WIP vs Lead Times

To consider safety stocks and production lead times, let

L(1) = the production lead time for System 1 in years

L(2) = the production lead time for System 2 in years

r(1) = the reorder point for System 1

r(2) = the reorder point for System 2

Z(a) = the number of standard deviations associated with an acceptable level of stockouts during the lead time, i.e., associated with a level of protection 'a' during the lead time

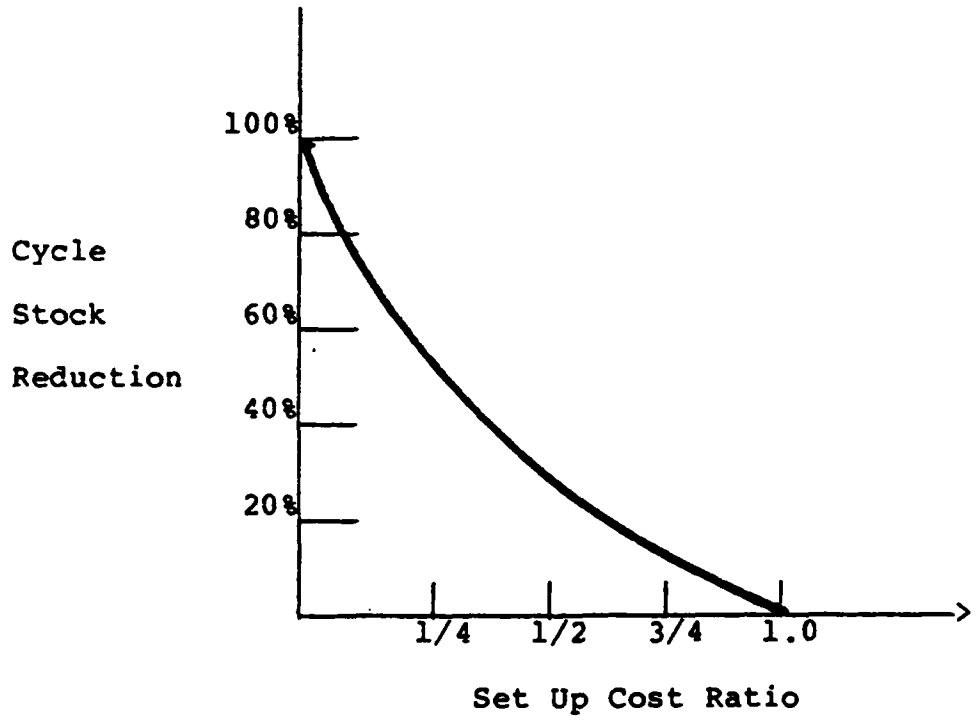

Figure 2.2 Reduction in Cycle Stock for Various Ratios of Set-up Cost

R(ss) = fractional reduction in safety stock resulting from a conversion from System 1 to System 2

D = demand rate in units per year

$S^2(d)$ = the variance of demand per year.

Assuming for this batch-size model that continuous review is used and that demand is independently and normally distributed (or equivalently, that demand during lead time is normally distributed), then

$$r(1) = L(1)*D + Z(a)*[L(1)*S^2(d)]^{1/2}$$

$$r(2) = L(2)*D + Z(a)*[L(2)*S^2(d)]^{1/2}$$

Therefore, with L(1) > L(2) we have

$$R(ss) = 1 - [L(2)/L(1)]^{1/2} .$$

Thus, as before, a 20 percent reduction in production lead times would result in approximately an eleven percent reduction in the amount of safety stocks necessary for the same probability of stockouts as illustrated in Figure 2.2.

2.1.4 Estimation of Potential Savings

Manufacturers are currently searching for ways to reduce WIP, and their efforts are focused primarily on reducing set-up costs or lead times. The previous sections have described the general non-linear relationship between these factors and average WIP reduction. More importantly, however, a dollar of

average WIP reduction means that the holding cost of that dollar is avoided as an expense. The result is a reduction in unit cost, as explained in detail in the interim report.

In the interim report it was stated that the potential dollar/manpower savings from improved production/inventory control systems were significant. But how significant? The Defense Audit Report No. 81-031, dated December 18, 1980, stated that "on December 31, 1979, the 7 AFPROs included in the audit had 159 contracts with unliquidated progress payments amounting to $3.2 billion." Unliquidated progress payments represent the value of property paid for by the government but not yet received, and this property, paid for but not received, is identical to "work in process" as used in this study. The annual cost for all 81 contractors with plant representative offices may easily exceed several billion dollars.

Translating this into interest payments the government incurs by having to borrow money to pay the cost of holding work in process inventory can be done as follows. Treasury bills maturing in six months were yielding approximately 9 percent on 1 March 1985. Using this rate the annual holding cost for the 7 AFPROs above is approximately $288 million per year.

The information on average unliquidated progress payments and average annual liquidation of progress payments is difficult to obtain. The AFBRMC asked all AFPROs to provide such data; however, only seven were able to respond with useful data. Table 2.1 summarizes the data for the reporting contractors; however, there is no assurance that this information is typical of the other manufacturers.

Table 2.1A

Contractor A

Progress Payments ($000,000)

Year	Total Liquidated	Average Unliquidated	Ratio
1980	15.7	5.2	3.02
1981	4.4	11.1	.40
1982	10.6	30.9	.34
1983	84.9	30.7	2.77

Table 2.1B

Contractor B

Progress Payments ($000,000)

Year	Total Liquidated	Average Unliquidated	Ratio
1980	64.5	39.7	1.62
1981	53.4	35.8	1.49
1982	73.1	44.4	1.65
1983	76.0	67.9	1.12

Table 2.1C

Contractor C

Progress Payments ($000,000)

Year	Total Liquidated	Average Unliquidated	Ratio
1980	---	---	---
1981	7.8	26.7	.29
1982	45.6	39.6	1.15
1983	33.5	40.0	.83

Table 2.1D

Contractor D

Progress Payments ($000,000)

Year	Total Liquidated	Average Unliquidated	Ratio
1980	7.6	104.0	.07
1981	224.0	91.9	2.44
1982	529.5	52.9	10.01
1983	573.5	79.1	7.25

Table 2.1E

Contractor E

Progress Payments ($000,000)

Year	Total Liquidated	Average Unliquidated	Ratio
1980	---	---	---
1981	2.8	2.2	1.27
1982	12.0	12.9	.93
1983	35.5	45.5	.78

Table 2.1.F

Contractor F

Progress Payments ($000,000)

Year	Total Liquidated	Average Unliquidated	Ratio
1980	---	---	---
1981	---	---	---
1982	15.3	54.0	.28
1983	110.7	94.8	1.17

Table 2.1G

Contractor G

Progress Payments ($000,000)

Year	Total Liquidated	Average Unliquidated	Ratio
1980	448.3	367.5	1.22
1981	480.2	178.0	2.70
1982	206.4	235.0	.88
1983	488.6	476.7	1.02

Table 2.1H

Contractor H

Progress Payments ($000,000)

Year	Total Liquidated	Average Unliquidated	Ratio
1980	---	109.5	---
1981	134.9	242.4	.56
1982	231.3	299.7	.77
1983	309.6	264.6	1.17

Table 2.1I

Contractor I

Progress Payments ($000,000)

Year	Total Liquidated	Average Unliquidated	Ratio
1980	25.1	---	---
1981	58.9	37.8	1.56
1982	148.4	97.5	1.52
1983	385.5	216.1	1.78

Table 2.1J

Contractor J

Progress Payments ($000,000)

Year	Total Liquidated	Average Unliquidated	Ratio
1980	---	---	---
1981	7.8	14.2	.53
1982	45.6	42.4	1.08
1983	33.5	49.6	.68

Table 2.1K

Contractor K

Progress Payments ($000,000)

Year	Total Liquidated	Average Unliquidated	Ratio
1980	1858.8	---	---
1981	2994.7	828.5	3.61
1982	3387.4	870.5	3.89
1983	3962.1	931.9	4.25

Table 2.2

Summary of Contractor WIP Ratio

Year	Contractor A	B	C	D	E	F	G	H	I	J	K
1980	3.02	1.62	----	.07	----	----	1.22	----	----	----	----
1981	.40	1.49	.29	2.44	1.27	----	2.7	.56	1.56	.53	3.61
1982	.34	1.65	1.15	10.01	.93	.28	.88	.77	1.52	1.08	3.89
1983	2.71	1.12	.83	7.25	.78	1.17	1.02	1.17	1.78	.68	4.25

Table 2.2 presents the ratio of liquidated to average unliquidated progress payments by year for each contractor. The ratio values range from .07 to 10.01 however contractors A and D account for most of this extreme variability. Contractors B and E appear to have stable ratios with means of 1.47 and 1.0 respectively. The available data is so limited that further statistical analysis is fruitless.

The Department of Defense conducted a study of contract pricing, financing and profit, and published its findings as the Defense Financial and Investment Review, June 1985. One of the difficulties faced by the study team was how to reach conclusions about such diverse products manufactured by the defense industry. "To analyze the working capital requirements of defense contracts, a 'typical' contract was created from the actual performance of selected contracts. Twelve recently completed contracts, representing major end-items (e.g., aircraft, missiles, vehicles, electronics) were used to build a composite cost and delivery profile." (Page IV-11) The "typical" contract's cash flow was summarized in Exhibit 8, page IV-16, partially reproduced here as Table 2.3, and included a sequence of progress payments, delivery payments and liquidation through delivery for a $10 million contract. The progress payments are incurred at a uniform rate over the contract's life. The contract covered 40 months and when analyzed showed average unliquidated progress payments

Table 2.3

Cash Flow Analysis of "Typical" Contract

Month	Costs Incurred	Process Payment Billed	Delivery Payment Billed	EOM Unbilled Inventory
1	$ 46,648	$ 41,983	$ 0	$ 4,665
2	74,137	66,723	0	12,079
3	83,300	74,970	0	20,409
4	188,552	169,697	0	39,264
5	250,576	225,518	0	64,321
6	271,250	244,125	0	91,446
7	271,250	244,125	0	118,571
8	271,250	244,125	0	145,696
9	271,250	244,125	0	172,821
10	271,250	244,125	0	199,946
11	271,250	244,125	0	227,071
12	293,583	264,225	0	256,430
13	306,743	276,069	0	287,104
14	311,130	280,017	0	318,217
15	311,130	280,017	0	349,330
16	311,130	280,017	0	380,443
17	311,130	280,017	0	411,556
18	311,130	280,017	0	442,669
19	311,130	280,017	0	473,782
20	311,130	280,017	0	504,895
21	308,632	277,769	0	535,758
22	307,161	276,445	0	566,474
23	306,670	276,003	0	597,141
24	306,670	276,003	0	627,808
25	306,670	276,003	0	658,475
26	306,670	276,003	0	689,142
27	306,670	276,003	0	719,809
28	306,670	276,003	0	750,476
29	306,670	276,003	0	781,143
30	258,835	232,951	0	807,027
31	230,646	207,581	0	830,091
32	221,250	199,125	0	852,216
33	221,250	199,125	0	874,341
34	221,250	199,125	250,000	646,466
35	221,250	199,125	0	668,591
36	221,250	199,125	250,000	440,716
37	221,250	199,125	0	462,841
38	143,998	129,598	250,000	227,241
39	98,474	88,627	0	237,089
40	129,115	0	366,203	0
TOTAL	$10,000,000	$8,883,796	$1,116,203	

of $3.8 million over the life of the contract, see table 2.5 model A. The ratio of contract cost to average unliquidated progress payments was 2.60 implying that the typical contract produced an average of 2.6 dollar's worth of product deliveries for every dollar of government-owned and financed WIP represented by average unliquidated progress payments. The typical contract developed by the DOD study team also implies that a $10 million contract generates average unliquidated progress payments of $3.8 million or 38 percent of the contract's price.

The DOD's study (page IV-28) states that in 1984, approximately $56.7 billion worth of contracts were let which contained progress payment clauses. By extrapolation from the analysis presented above, these contracts *should* produce average unliquidated progress payments of approximately $21.5 billion ($56.7 x .38). This also suggests that the government's cost to finance these unliquidated progress payments or WIP at 9 percent treasury rates should be roughly $1.935 billion per year ($21.5 x .09). As developed earlier, any action which can be taken to reduce average WIP would directly reduce the government's cost to finance WIP.

The limited data do not permit a precise estimate of savings which could result in improving WIP management. The DOD study's typical contract implied a ratio of annual liquidated to average unliquidated progress payments of 2.6,

whereas the seven contractors who provided comparable data had ratios of .07 to 10.01. Contractors B and E appear to be stable with WIP ratios of 1.0 to 1.47. If 1.5 is a representative ratio for all contractors, then if contractors adopted a turnover goal of 2.0 and achieved it, this would yield an estimated government saving of nearly $800 million for the 1984 contract data and assumptions, i.e., reduce holding costs from $3.4 down to 2.6 billion (table 2.4). It is quite possible that aggressive contractor efforts could improve this measure of productivity above the 2.0 level. Table 2.4 gives the government's cost of financing WIP for different turnover measures at an interest rate of 9 percent.

Table 2.4

Projected WIP Holding Costs (1984)

($000,000,000)

Contract Value	Average Unliquidated Progress Payments	Ratio	Holding Cost
$56.7	$56.7	1.0	$5.1
56.7	37.8	1.5	3.4
56.7	28.4	2.0	2.6
56.7	22.7	2.5	2.0

2.2 Contract WIP Profile

The previous discussion of WIP levels assumed that ratios were calculated at the corporate level where a number

of contracts were managed as an aggregate. An alternative view is to look at a single contract and the government's cost of financing WIP over the contract's life. By assuming that the Department of Defense's cost, schedule and per-formance standards are constant; then the Treasury's cost of financing WIP is dependent upon the pattern of progress payments. Progress payments in turn are dependent upon the pattern of incurred costs implicit in a contractor's production and procurement schedule.

A particular sequence of progress payments will produce a unique profile of unliquidated progress payments. The associated WIP profile in turn can be translated into a standard measure of holding cost over the entire life of a contract. One can develop such a measure in terms of the present value of the stream of unliquidated progress payments by using the appropriate discount rate to arrive at the present value of holding cost for a particular WIP profile. The same WIP profile and interest rates can be used to calculate the future value of holding cost at a contract's end. Either of these measures can be used to compare WIP profiles in terms of the actual cost to the Treasury Department. Since the Department of Defense's cost, schedule and performance goals are assumed constant, then the WIP profile which has the lowest value of either of these standard measures is most desirable from the government's viewpoint.

It is important to recognize that WIP, as defined in this study, is property which is owned by the government but not yet received. In simple terms, a contractor is managing Department of Defense assets but the cost of a contractor's actions are mixed in with the Treasury Department's cost to finance the federal debt. The two standard measures described briefly above can be used to determine just how effective a contractor was in managing WIP after a contract is completed. The remainder of this section will describe the calculation of the future value of WIP holding cost for a given contract's WIP profile and its use in various models.

2.2.1 Future Value of WIP Holding Costs

Define as follows:

h = annual holding cost rate

r = annual cost of capital rate

I = average annual WIP value

For our purposes, both rate variables are the same since the cost of capital rate is the Treasury Department's cost of short term debt and the holding cost rate is at least equal to this value. The cost to hold WIP for a year is hI and the present value of this holding cost payed at the end of year one is:

$$PV = (1 + r)^{-1} hI.$$

The use of average inventory implies that it is constant throughout the year. As a result, one can consider an alternative where holding costs are incurred at the end of each month with inventory still constant throughout the year. The holding cost in this situation is less, since it is payed monthly. By considering a monthly holding cost rate h we can obtain the present value of a series of twelve consecutive equal monthly holding cost payments from the following equation:

$$PV = h\, I \sum_{x=1}^{12} (1 + r)^{-x/12}$$

The conventional use of holding cost implies that these two statements about the present value of holding cost are equivalent. The annual holding cost rate and the annual cost of capital are known, therefore, we can determine the monthly holding cost rate by setting the two expressions equal and solving to obtain:

$$h = h/(1 + r) \sum_{x=1}^{12} (1 + r)^{-x/12} .$$

The monthly holding cost rate can now be used to determine the change in present value of holding costs which are generated by changing the pattern of progress payments. In a general form, the present value of a series of n

monthly holding cost payments, not necessarily equal, can be calculated from:

$$PV = h \sum_{x=1}^{n} I_x \, (1 + r)^{-x/12} \, .$$

The future value of a series of monthly holding cost payments can be derived in a similar fashion, and produces the following equation.

$$FV = h \sum_{x=1}^{n} I_x \, (1 + r)^{(n-x)/12} \, .$$

2.2.2 Future Value vs WIP Profiles

The typical contract used in the defense study cited earlier covered 40 consecutive months for a total contract value of $10 million. The series of progress payments given in table 2.3 were used to calculate the average unliquidated progress payments at a payment rate of ninety percent of incurred costs and one month to pay after billing. Actual holding costs of this inventory were obtained by using an assumed holding cost rate of 9 percent. The future value of the monthly holding costs was calculated by using the same 9 percent rate of government interest. These statistics are presented in table 2.5 as version A along with the ratio of contract cost, $10 million, to average unliquidated progress payments over the contract's life. It is important to

recognize that this typical model had four delivery points of equal value occurring in months 34, 36, 38 and 40.

The typical model was then modified so that all costs were incurred at a uniform rate for each production group leading to delivery. Production was assumed to start 34 months prior to delivery; i.e. months 1, 3, 5, 7; and the average cost for each batch was identical. The descriptive statistics for this model, version B are presented in table 2.5.

Table 2.5

DOD's Typical Contract Model

($000,000)

Cost Version	Average Unliquidated Progress Payments	Actual Holding Cost	Future Value Holding Cost[1/]	Ratio Contract/ UPP
A	$3.849	$1.102	$1.215	2.60
B	3.789	1.085	1.197	2.64
C	6.715	1.922	2.177	1.49

[1/] Treasury interest rate of 9 percent.

Version C of the typical model uses the assumptions of version B except for material costs which are incurred at the beginning of each production period leading to production. The defense study used a material cost rate of 68.75

percent of contract cost; this includes all related overhead expenses.

The results of these three versions of the defense study's typical model indicate that the average unliquidated progress payments increase as costs are incurred earlier as in version C. The ratio of contract cost to average unliquidated progress payments decreases as costs are incurred earlier and both the actual and future value of holding costs can be calculated.

The concept of a typical contract provides an excellent model to use in exploring the changes in WIP under varying conditions. This approach was taken in this study with one simplifying assumption: that all deliveries will occur at one point, the end of month forty. The total contract cost of $10 million was retained along with the use of 44 percent for material costs, 20 percent for direct labor costs and 36 percent for indirect and overhead costs. The indirect and overhead costs were allocated proportionally among material and direct labor costs. The material costs and its overhead rate are 68.75 percent of the total contract costs and the direct labor rate with its overhead costs are 31.25 percent. Progress payments were calculated as 90 percent of incurred costs and a one month delay was assumed between billing by the contractor at the end of each month and actual payment by the government. Work in process, in the form of unliquidated progress payments, continued from the point

that the government actually made a progress payment until the item was delivered to the government, in this case the end of month forty. A number of different patterns of progress payments were examined to determine the effect upon (a) the average unliquidated progress payments over the entire 40-month contract, (b) the actual holding costs incurred over the contract, (c) the future value of all holding costs and (d) the ratio of total contract costs to average unliquidated progress payments. Five of these models are described in the following paragraphs and the above descriptive statistics presented in table 2.6.

Table 2.6

Single Delivery Point Model
($000,000)

Model	Average Unliquidated Progress Payments	Actual Holding Cost	Future[1/] Value Holding Cost	Ratio Contract/ UPP
One	$4.168	$1.193	$1.315	2.40
Two	4.495	1.287	1.424	2.22
Three	7.180	2.055	2.352	1.39
Four	7.504	2.148	2.460	1.33
Five	8.550	2.447	2.824	1.17

[1/] Treasury interest rate of 9 percent.

Model one assumes that all costs are incurred at a uniform monthly rate over the entire 40-month contract. Model two caused material costs to occur two months earlier than in model one and 50 percent of direct labor costs to

occur one month earlier than the uniform rate of model one. Model three caused all material costs to occur in month one and direct labor costs to occur at a uniform monthly rate over the contract's life. Model four incurred all material costs in month one and direct labor costs six months earlier than the uniform rate model. Model five is an extreme case where all costs are generated in month one with delivery still at the end of month forty.

The descriptive statistics given in table 2.6 demonstrate the increase in WIP holding costs as costs are incurred earlier in a contract. The data also clearly shows the relationships between these costs and the ratio of a contract's cost to its average WIP over the contract's duration. If a contractor's business is in a steady state with a mixture of contracts just starting, nearing completion and in the middle of their life, then the ratio of average annual liquidation to average unliquidated progress payments will measure WIP performance. For example, if the ratio is near one as in model four, then costs are being incurred very early in a contract relative to a uniform rate of cost generation. On the other hand, if the ratio is above 2.0, then costs are being incurred at a more uniform rate. None of this should be construed as a standard. This will depend upon the pattern of deliveries with each contract, the mix of government contracts with a firm and other variables. It is still possible, however, to

examine each contract by looking at its known contract duration and delivery schedules. By assuming a uniform rate of cost occurrence, then standards could be developed for each of the descriptive statistics given here and used to measure how effective a contractor had been in managing WIP. This will occur after a contract is completed but it could form the basis for developing an incentive clause so that a contractor is rewarded for reducing WIP holding costs or penalized for costs above the standard.

The limited data concerning the actual ratio of annual liquidated progress payments to average unliquidated progress payments suggests that the ratio is in the neighborhood of 1 to 1.5 (Table 2.1). Table 2.6 data shows that if contractors can be induced to improve their management of WIP so that the WIP ratio increases from 1.33, model four, up to 2.22, model two, then actual holding costs over forty months for a $10 million contract would decrease by some $861 thousand. This decrease translates to approximately 8.6 percent of the contract's cost over the contract's life. By extrapolation, this rate of savings could be very significant since annual defense contracts are placed which exceed $56.7 billion in total. The limited analyses of data from the single delivery point model and the multiple delivery point typical model indicates that the ratio of contract cost to average unliquidated progress payments are influenced by the number and timing of

deliveries. For example, a contract with one delivery point at the contract's end will produce a ratio of contract cost to average unliquidated progress payments of 2.4 over the contract's life under the following assumptions:

a. Uniform rate of incurring costs,

b. Progress payments are billed at the end of each month,

c. Progress payments are made at the end of the month following billing,

d. Progress payments are made at ninety percent of incurred costs,

e. Contract life is 40 months.

A contract with two or more delivery points over the contract's life will produce ratios above 2.4 under the assumptions listed above. This suggests that a goal of 2 or better for this WIP ratio might be adopted for WIP management until more extensive analysis of existing contract data is completed.

2.3 Summary

This chapter has presented a representative inventory or lot size model to demonstrate the change in average WIP which will result from changes in set-up times and lead times. Reductions in either or both factors will reduce average WIP in a non-linear way. A reduction in average WIP, in turn, reduces WIP holding costs by the same proportion, where holding cost is at

least equal to the Treasury Department's cost of borrowing short-term government funds. Information from seven contractors suggests that a typical defense contract may have a ratio of annual liquidated to average unliquidated progress payments (WIP) of 1.5. A ratio of 1.5 would imply WIP holding costs of $3.4 billion on contracts of $56.7 billion for 1984. This holding cost, borne by the Treasury Department's borrowing, could be reduced as average WIP is reduced. These arguments indicate that by using a ratio of annual liquidated to average unliquidated progress payments, government representatives can monitor how effective contractors are in managing government-owned WIP represented by average unliquidated progress payments.

The chapter also developed a method for determining the future or present value of a particular series of monthly unliquidated progress payments. This method uses the Treasury Department's cost of short term debt as both a holding cost rate and interest rate for compounding. The resultant future value permits precise evaluation of how effective a contractor was in managing government owned WIP.

CHAPTER III

Effects on Surge and Logistics

3.0 Introduction

Task three of Phase II states: "Identify and develop strategies to prevent adverse cost, schedule or performance impact on logistics support resulting from changes to production/inventory control systems." In addition, the AFBRMC asked that the study "... consider the implementation of surge as a DOD objective. Show where surge begins and good WIP control ends."

The Air Force Systems Command has the primary responsibility for acquiring new weapon systems and the Air Force Logistics Command has the primary responsibility for supporting a weapon system after it has become operational. Both commands use the same population of contractors, subcontractors and vendors to fulfill their responsibilities. Government and private studies of the Defense Industrial Base recognize the interdependencies of these production processes, and therefore they will be addressed jointly as surge potential in the remainder of this chapter. Government studies will be summarized to illustrate the current surge potential of the United States'

industrial base and their arguments presented to identify those items which should be prime candidates for improved WIP management.

3.1 Surge Potential

Numerous studies have been completed during the last few years to determine whether the United States has the industrial capacity to quickly increase production in support of war time needs. All the studies have concluded that the nation does not have surge potential or at best only limited surge potential. This section will discuss only the more prominent reports of the House of Representatives, Senate, Defense Science Board, and the Air Force to support the widely accepted conclusion of limited surge potential.

The Defense Industrial Base Panel of the Committee on Armed Services, House of Representatives, published its report on "The Ailing Defense Industrial Base: Unready for Crisis" on 31 December 1980. The panel found that "... the industrial base is not capable of surging production rates in a timely fashion to meet the increased demands that could be brought on by a national emergency." (page 11) Among the more significant testimony given in the report were several statements made by defense executives. For example,

Dr. William J. Perry, Under Secretary of Defense for Research and Engineering, stated: "We do not have a surge capability; that is if we wanted to double the production rate of F-16's, in three months or six months, there is no way we can do it." (page 12) General Alton D. Slay, Commander, Air Force Systems Command, stated that "... after nearly 18 months under surge conditions, we could only expect to get an aggregate of 22 more A-10's and no additional F-15's and F-16's than already exist on the currently contracted delivery schedule." (page 12) Mr. Dale Church, Deputy Under Secretary for Defense Acquisition Policy, cited "... very serious deficiencies at the first, second, third, and so on and so forth, tiers of subcontractors down to the vendor levels who are vendoring components into the team." Lead times were frequently cited as basic causes of lack of surge capability with aluminum forgings lead times increasing from 20 to 120 weeks, landing gears from 52 to 120 weeks, integrated circuits from 25 to 62 weeks, and jet engines from 76 to 164 weeks. The testimony from government and industry appeared to fully support the panel's conclusion that the country does not currently have a surge capability.

The House report cited above emphasized the plight of subcontractors and vendors who provide the material

and components to the prime contractors. The Committee on Small Business, United States Senate, conducted a series of sessions on surge capability and published a report of its hearings on the Deterioration of the U.S. Defense Industrial Base on 14 July 1981. Senator Lowell P. Weicker, Jr., outlined the problem clearly, as follows: "The subtier is comprised of thousands of small business contractors who actually form the foundation of the defense industry, supplying high technology raw materials, components, subassemblies, and subsystems that could not be produced efficiently by the larger companies. In recent years there has been mounting evidence to show that this defense supplies-contractor infrastructure, upon which much of our defense production capability rests, is approaching the limits of its capacity....we are beginning to see production bottlenecks, caused in large part by the larger lead times needed by subcontractors to supply necessary parts and equipment." (page 1) Among the many issues included in the report, the problems of the machine tool industry seemed to be small in size but critical in impact. The report stated "Machine tools provide the basis for production of all military hardware. However, only a fraction of the nation's machine tools are capable of efficient and timely production of today's sophisticated weapon system."

(page 226) It further stated, "It is doubtful whether the American machine tool industry could respond to sudden mobilization or surge requirements." (page 230) The Senate's committee report supports the conclusion that industry below the prime contractor level does not have surge capability.

The Report of the Defense Science Board 1980 Summer Study Panel on Industrial Responsiveness was published in January 1981 by the Office of the Under Secretary of Defense for Research and Engineering. The report included the following as major findings: "Lead times have increased markedly in the last three years, ... the subcontractor and supplier base has decreased, ...[and] the defense industry has little or no capability to surge production in the short term." (page xvi) One measure of capacity and therefore surge potential is the number of suppliers. Table 3-1 is reproduced from Table IV-1 of the panel's report and indicates the limited number of suppliers available for several basic materials or components. The items listed in table 3.1 become even more critical because, as the panel's report stated, "In most cases, all these suppliers are at capacity and have substantial backlogs." (page 49) All of these factors interact to limit surge capability by increasing lead times. The panel's report in Figure IV-9 shows that lead times

for titanium bolts have increased from 32 weeks in 1976 to 62 weeks in 1980. At the systems level, the report in Figure IV-6 indicates lead times as follows: F-15 at 41 months, driven by landing gear components; F-16 at 42 months, limited by servo actuators; and A-10 at 49 months, limited by landing gears.

Table 3.1

Item	No. of Suppliers
Aluminum plate	2
Aluminum tubing	2
Titanium sheet	3
Titanium wing skins	2
Titanium extrusions	1
Air frame bearings (special)	1
Needle bearings	2
Connectors (mil. spec.)	3
Aircraft landing gear	3
Radomes	2
Image converter tube	1
Periscope lenses	2
Optics coatings	1

The Air Force has also completed numerous studies on surge capability. General Bryce Poe II, Commander of the Air Force Logistics Command (AFLC) in an article published by National Defense, Vol LXV, April 1980, recognized the serious nature of the problem indirectly by identifying several AFLC actions to "... allow quick response from industry if we need to surge." These actions would include "...advance buy of long lead-time materials in a semi-finished state, ...'near net shape'

forgings and scrap recovery." The Aeronautical Systems Division (ASD), Air Force Systems Command, in its Executive Brochure on Blueprint for Tomorrow (1984), indicates that the major contractors "... are currently running well below capacity--most of them in 40-50% range." (page 19) The report, however, concludes that subcontractors in the aerospace fields have limited surge potential and that "... aircraft, engines and missiles all 'drink from the same well'. That is, there are numerous common products that all three major groups rely on from the subtiers. These include forgings, castings, bearings, activators and electronics components. During periods of increased peacetime demand or during a surge, these products often become critical bottlenecks." (page 26) The dominant conclusion regarding surge is that the "Aerospace Base cannot surge and sustain without extraordinary measures." (page 46) The Electronic Systems Division (ESD), Air Force Systems Command, is currently engaged in analyzing the defense industrial base under a project titled Pursuit 2000. "After more than a year's study, the Electronic Systems Division at Hanscom AFB, Mass., has concluded that the nation's electronics industry would fail in attempting to provide essential components in a wartime emergency." (Air Force Times, August 5, 1985, page 47) These

findings are even more critical since the ESD is looking at surge and production for precision guided munitions. If the electronics industry cannot surge, then the precision guided munitions industry cannot surge. These selected and current Air Force studies clearly show that the defense industry lacks the ability to increase production in the event of an emergency or war.

3.2 WIP Management vs Surge

The studies cited above all recognize how surge potential is limited by lead times. If, for example, an aircraft has a component with a 40-month lead time, then output cannot be increased until 40 months after a decision is made to increase production. This study was not conducted in sufficient depth to assess how well the two contractors, who were visited, managed critical items, where "critical" invariably means "short supply," implying long lead times. The impression gained from both production and procurement personnel, however, suggested that critical items were closely managed and expedited when possible. If this is correct, then one might observe that such critical items are already driven to a point approaching minimum WIP. In contrast, the other less critical items in terms of lead times, are simply pursuing their normal

course through the system. These items are prime candidates for improved WIP management. As a starting point, one might impose an aggressive WIP management program on all parts and material with lead times less than 24 weeks. This 24-week figure was selected because all the reports cited above listed lead-time-critical items at more than 24 weeks.

3.3 Summary

This chapter has shown that the defense industrial base lacks the capacity to surge to meet emergency or war time needs. The major limitation lies at the subcontractor and vendor level, where lead times of material and components may exceed 40 months. The chapter also suggests that lead-time-critical items are probably already managed intensely, such that they are at minimum WIP levels. It is possible, however, to apply an aggressive WIP management program to material and components which are not lead time critical, e.g., 24 week lead times or less.

CHAPTER IV

Implementation

4.0 Introduction

Tasks two and four of Phase II state "Develop review procedures for DOD contract administration people to use in evaluating production/inventory control and associated management systems. These procedures will include, but not be limited to, the performance measures and savings estimation techniques developed in 4.1.1 and 4.1.2.1." and "Develop an implementation guide for application of the measures, techniques, procedures and strategies developed in 4.1.1, 4.1.2.1, 4.1.2.2 and 4.1.2.3. This guide will assist system program office and contract administration people in implementing the measures, techniques, procedures and strategies." The interim report recommended that the CMSEP be used to implement the study's findings and it was approved. This chapter proposes a simple addition to the CMSEP which will focus a contractor's attention directly on WIP levels and on those planning factors which are crucial to efficient procurement and production planning. The CMSEP is not mandatory, however, all contractor's cooperate voluntarily with their resident AFPRO's in using the program to monitor contract performance.

There are in general terms, two approaches to the problem of WIP management. One method is to become actively involved in a contractor's production and procurement process to insure that effective procedures are used. Alternatively, one can select a measure or measures of effective WIP management and include this in the contract as an incentive clause. This latter approach would minimize the government's intrusion into a contractor's management system but could motivate it to reduce WIP holding costs. Both approaches are discussed in subsequent sections of this chapter as a proposed modifications to CMSEP and as a proposed WIP incentive clause.

4.1 Proposed CMSEP Modifications

The Contractor Management System Evaluation Program requires that an AFPRO's Manufacturing Operations Division monitor a contractor's manufacturing operations. The program includes ten management systems indicators but only two of these are relevant to this study's topic. They are "PD3 Does the contractor have an adequate Manufacturing Planning System?" and "PD6 Does the contractor have an adequate system for forecasting, scheduling and controlling workloads?" PD3 has two subordinate condition questions and PD6 has five condition questions. Each AFPRO's Manufacturing Operations Division develops unique Adequacy Criteria which focus attention on those items that are

deemed important for each condition question. This approach is vital because there is so much diversity among contractors. However, the condition questions as they are currently written and used do not address WIP management. The following management system indicator and seven condition questions would be added to the responsibilities of each AFPRO's Manufacturing Operations Division under the CMSEP.

4.1.1 Management System Indicator

PD-X Does the contractor have an effective system to manage unliquidated progress payment material?

NARRATIVE: Unliquidated progress payment material includes all material paid for by the government through progress payments but not yet delivered to the government. The government finances this material, sometimes referred to as work-in-process and programmed storage inventory, and it is important to keep it at a minimum level commensurate with meeting a contract's schedule and performance requirements.

Effective evaluation of this MSI requires the evaluator to determine that the contractor's written procedures establish realistic goals for the following measures and that satisfactory progress is made toward these goals.

a. Minimum work in process inventories.

b. Accurate procurement and production lead time planning factors.

c. Accurate bills of materials.

d. Accurate routing documents.

e. Accurate inventory records.

f. On time vendor's and subcontractors' deliveries.

g. On time contractor's deliveries.

SUGGESTED GOALS:

a. The ratio of total contract cost to average unliquidated progress payments for completed contracts must exceed one and should exceed two and one-half to obtain acceptable low work in process inventories.

b. The accuracy and delivery measures should approach 100 percent. Values below 99 percent should be examined to determine why performance is low.

4.2 WIP Incentive Clause

The series of monthly holding costs incurred by the government as it finances work in process can be determined after a contract is completed. The future value of this series of costs can also be calculated and implies that a dollar of holding cost incurred in the first month has a greater cost to the government than one incurred in the last month of a contract. The future value of a contract's holding costs will depend upon the particular pattern of deliveries specified in the contract, where progress payments are liquidated, and also the timing of incurred costs controlled by a contractor, which create unliquidated progress payments. A target for the future value of WIP

holding costs on a new contract can be determined by using the basic concepts developed in Chapter III and by assuming a uniform rate of cost generation up to each specified delivery point. An incentive clause could then be written to permit a contractor to share in the savings if actual WIP holding costs are less than the target or alternatively, share in the added cost if the goal is exceeded. The clause could also serve as a powerful factor to encourage contractors to develop and use more efficient-effective production and procurement management systems.

4.3 Summary

A proposed addition to the CMSEP is given in section 4.1.1 which would encourage a contractor to measure the level of unliquidated progress payments and the accuracy of critical planning factors used in procurement and production planning. Specific standards were not recommended because the data available for analysis was inconclusive. A recommendation was also made that an incentive clause be developed which would allow a contractor to participate in savings when WIP holding costs over a contract's life are less than a negotiated target or bear a portion of the costs when the target is exceeded.

CHAPTER V

Conclusions and Recommendations

5.0 Conclusions

This study has produced the following findings.

a. Unliquidated progress payments, referred to as work in process throughout this study, cost the Department of the Treasury over three billion dollars per year to finance.

b. Contractor and government personnel are primarily concerned with a contract's schedule, performance and cost to the Department of Defense.

c. Excessive work in process increases the cost to hold such inventories but has only a marginal contribution to increasing the ability to meet schedule goals.

d. Effective and efficient procurement and production planning depends upon accurate planning factors.

e. The cost to finance work in process can be determined after a contract is completed by using the interest rate on short term government debt.

f. A target for work in process holding costs can be determined during contract negotiation and used with an incentive clause to reduce work in process holding costs.

5.2 Recommendations

The following actions should be taken to improve defense contractors' management of government owned work in process.

a. Implement the CMSEP management system indicator described in section 4.2 of this report.

b. Develop an incentive clause to encourage defense contractors to reduce the government's cost of financing work in process.

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